UNITED
NATIONS

A

United Nations Conference on New and Renewable Sources of Energy

Nairobi, Kenya
10-21 August 1981

UN LIBRARY

JUN 24 1981

UN/SA COLLECTION

Distr.
GENERAL

A/CONF.100/NR/ 41 *
2 June 1981

ENGLISH ONLY

NATIONAL REPORT SUBMITTED BY

EGYPT**

National reports are reproduced by photo-offset and issued in the languages of mission only. This document will receive full distribution at Headquarters. ly two copies per delegation will be available at the Conference site.

The designations employed, the presentation of material and the views expressed this paper are those of the submitting Government and do not necessarily reflect practices and views of the Secretariat of the United Nations in any of these pects.

1- Country Basic Data

1.1. Egypt covers an area of about one million square kilometers of which the Nile Valley represents only 4%. The total cultivated area is about 30.000 Km^2 and much of the country's efforts today is directed toward land reclamation and building new cities in the non-cultivable areas.

1.2. Present population is nearly 42 millions and is expected to reach 66 millions by the year 2000. Rural population represents about 55% of the total, and with intensive efforts for industrialization and the mechanization of agriculture this percentage is expected to go down.

1.3. For the fiscal year 1980/1981, GNP in current market prices is estimated at 16266 million L.E. (Egyptian pounds)(x), GDP is estimated at 14508 million L.E. and the per capita GDP at 345 L.E. or nearly $490.

1.4. The following is a tentative percentage distribution by sector of the GDP for the year 1980/1981:

Agriculture	20.6
Petroleum	18.5
Industry	13.2
Trade and Finance	17.2
Public & Social Services	14.9
Suez Canal & Tourism	5.2
Transportation and Communications	3.6
Construction	4.7
Others	2.1
	100.0

(x) one US $ = 0.70 L.E.

1.5. For the fiscal year 1980/1981 Egypt's imports are estimated at 5413 million L.E., of which 72% is capital and intermediate goods and 28% is consumer goods. Invisible payments are estimated at 440 million L.E., to bring total current foreign payments to 5853 million L.E.

Total current foreign revenues are estimated, for the same year, at 5019 million L.E. Nearly 44% of these revenues are invisible (Suez Canal, tourism, transfers by expatriates and other sources), 38% by petroleum exports and 18% by industrial and agricultural exports.

The balance of payments is expected to reveal a deficit of about 834 million L.E. (nearly $1200 million) down from a deficit of 1095 million L.E. ($1565 million) a year before.

1.6. The central government's domestic revenue is expected to reach 5925 million L.E. during the fiscal year 1980/1981. Current expenditures are expected to equal domestic revenues. In addition, capital expenditures are estimated at 3200 million L.E. ($4570 million) to be financed by revenues from export sectors (mainly petroleum, Suez Canal and tourism).

1.7. The transition from a war economy to a development-oriented peace economy has led to a re-orientation of priorities in the Five-Year Development Plan. The details of the new 1980/81-1984/85 Plan are not yet available, but its total planned investment is estimated at nearly 25 billion L.E. The Plan aims at accelerating the GDP at an average rate of 10% per annum, compared with nearly 8% during 1978 and 1979. Greater emphasis is given to economic and social infrastructure, mainly to cope with one of the major problems, ie, the alarming increase of population. Investment needs for rural development are given a priority, and measures have been taken to regionalize and decentralize development efforts.

The Five-Year Plan major break-down is as follows:

	%
Housing and related infrastructure	21.0
Transport and communications	17.5
Agriculture and food security	19.2
Export sectors (oil, Suez Canal, tourism)	13.5
Industry	11.1
Social services (education, health, etc.)	9.5
Development of non-oil energy supplies	6.9
Others	1.3
	100.0

1.8. Foreign investments and assistance play an important role in investment financing, but a major shift in the use of domestic resources aims at financing an average of 65% of the Plan's requirements.

2- Energy Demand and Supply

2.1. Present Energy Demand

The commercial primary energy demand in Egypt has increased during the period 1952-1981 from nearly 3 million tons of oil (with no hydropower) to nearly 17 million tons of oil equivalent (toe), with hydropower accounting for nearly 20%. Petroleum products account for the remainder. Out of the 80% petroleum share, nearly 16 percentage points go into thermal electricity generation, thus bringing the total share of electricity to 36%. A rough estimate of present non-commercial energy sources may be in the order of 3 million toe, thus bringing the gross total primary energy demand in 1981 to about 20 million toe.

One of the most alarming aspects in recent years has been the fast growing rate of energy consumption as indicated by the figures in tables (1) and (2) reflecting electricity and direct petroleum products consumptions. For the period 1975-1981, the average annual rate of growth in consumption has exceeded 11% for petorleum and 14% for electricity. As two thirds of the Nile's ultimate hydropower potential are already developed and utilized, thermal power generation has been growing in recent years at an annual rate of nearly 21% per annum.

2.2. Future Demand Forecasts: Several efforts have been undertaken during the past few years to assess energy to the year 2000. Two of these studies have already been published. The first was undertaken in 1976 by the Specialized National Councils and is available in Arabic. The second was completed in 1978 by a joint Egypt/US group and is available in English. A third study is still in progress and is carried out by one of the working groups of the Supreme Council for Energy.

Currently, Egypt is trying to establish adequate capabilities which may help improve and update these studies. In this area, much of international co-operation is expected to be accomplished in the near future.

Total projected demand for primary commercial energy by the year 2000 is tentatively estimated at nearly 65 million tons of oil equivalent. This would be nearly 3.8 times the current primary commercial energy consumption, or an average rate of consumption growth of nearly 7.5% per annum during the period 1980-2000.

Table 1- Domestic Consumption
of main Petroleum Products
(1952-1981)
(Units = 1000 Metric Tons)

Year	Natural Gas	Buta-Gas	Gasoline	Kerosine	Gas Oil	Fuel Oil	Lubricants & Asphalt	Total
1952	-	4	252	665	343	1754	39	3057
1960	-	20	262	736	786	2783	158	4745
1965	-	59	287	928	1124	2974	209	5581
1970	-	108	444	820	1176	3005	297	5850
1975	33	179	656	1188	1335	3639	231	7261
1979	946	381	1148	1569	2175	4704	350	11273
1980/ 1981 Est.	-	-	-	-	-	-	-	13500

Table 2- Domestic Consumption of Electric Power
(1952-1981)

Year	Power Consumption (million kwh)			Peak Load MWe
	Thermal	Hydro	Total	
1952	929	-	929	110
1960	2829	250	3079	533
1965	3262	1738	5000	750
1970	2225	4690	6915	1100
1975	3009	6790	9799	1733
1980/1981 Est.	8500	10000	18500	3600

A rough break-down of the 65 million toe would be as follows:

a- Demand for electricity is expected to reach nearly 105 billion kwh based on the assumption that the per capita share will increase from its current level of 450 kwh to the world average of 1600 kwh. Expressed in terms of primary energy requirements, this may range between 28-30 million toe.

A break-down of electricity demand is expected to be:

(i) Hydropower 15 billion kwh or nearly 14%.
Currently, 10 billion kwh are provided by the existing hydropower system. An additional amount of some 5 billion kwh is planned to the year 2000. This is equivalent to nearly 1.5 million toe.

(ii) Nuclear energy 40 billion kwh or nearly 38%.

(iii) Thermal generation by oil, natural gas or imported coal, 50 billion kwh or nearly 48%.

b- New and renewable sources of energy (NRSE), other than hydro and noncommercial, are expected to provide nearly one million toe by 2000. If added to this, the above mentioned 1.5 million toe of new hydropower, the total commercial NRSE would account for about 4% by 2000.

c- Direct consumption of oil and natural gas is expected to be in the order of 34-36 million toe. If added to this, thermal electricity generation which is estimated at nearly 13-15 million toe, the total oil and natural gas requirements would amount to nearly 50 million toe.

2.3. Energy Supply: Several energy sources are available in Egypt with varying potentialities. The most important of these are oil, natural gas, hydropower, solar, biomass, coal and wind.

2.3.1. Oil: Exploration activities have been intensified since 1973, and a number of new discoveries have added nearly 2.5 billion barrels to proven reserves. More than $ 1100 million have been spent on oil exploration during 1973-1980. Production of oil and natural gas has increased during the period 1974-1981 from 7.5 million tons to 32 million tons. However, as previously mentioned, domestic consumption during the same period has grown from 6.5 million tons to nearly 13.5 million tons, and may reach nearly 50 million tons by 2000.

2.3.2. Natural Gas: Recent exploration activities have resulted in the discovery of several fields of dry natural gas. A pipeline is already under construction to gather and utilize associated gas which has been increasing with growing oil production. Hence, the amount of natural gas produced and utilized has rapidly increased from 33 thousand tons in 1975 to nearly 2 million tons in 1980. It is anticipated that natural gas will play an increasingly important role in the energy mix. To accelerate this role, the Egyptian concessions terms have been recently modified to allow for more incentives to encourage foreign companies to explore for natural gas.

2.3.3. Hydropower: Two thirds of the Nile hydropower have already been utilized with the installation of nearly 2475 MWe at the High Dam and Aswan Dam. Ongoing plans aim at the construction of a second station at Aswan and the utilization of several minihydro sites along the river. A pumped-storage project at Suez is being studied with a view to meet peak loads, and the planned Qattera Depression Project may provide additional capacity of nearly 600 MWe before 2000.

2.3.4. Nuclear Energy: Being cheaper to generate electricity by nuclear reactors than by oil-fired stations, Egypt plans to build nuclear reactors with a total capacity of nearly 8000 MWe by the year 2000. These would provide nearly 40% of the country's demand for electric power.

Agreements for bilateral cooperation in the field of peaceful uses of nuclear power have recently been concluded with France and the United States. Legislative measures are being taken to allocate nearly $500 million per annum from oil revenues to help finance the nuclear reactors programme whose financial requirements may exceed $20 billion during the period 1980-2000. Uranium, thorium and other radioactive material have been discovered in Egypt, but a great deal of efforts is needed to evaluate the techno-economic feasibility of such deposits and to explore for new ones. A special authority for nuclear materials is being established under the chairmanship of the Minister of Industry to accelerate such activities.

2.3.5 <u>Coal</u>: Few coal deposits were discovered in Egypt with estimated reservers in the range of 80 million tons. Al-Maghara coal mine in Sinai is being studied for immediate development and utilization (with nearly 35 million ton reserves). A programme for coal exploration in several areas is underway, and Egypt may soon be importing coal for electricity generation.

Coal is already imported as a feedstock for steel industry in amounts totalling one million tons at present and are expected to reach 5.5 million tons by 2000.

2.3.6. New and Renewable Energy: Egypt has very good prospects in several new energy sources. The most promising of these are solar energy and biomass. Wind energy is available with good potentiality and geothermal energy is being explored with a view to assess its potentiality.

Section (4) of this paper will discuss these new and renewable energy sources in detail.

3- Institutions and Policies

3.1. Up till the mid seventies, energy activities in Egypt were handled on the production side by two separate ministries: The Ministry of Petroleum and the Ministry of Electricity. All other energy consumers, public or private, merely contacted either one for their needs and little was done to coordinate such activities.

However, the alarming acceleration of energy consumption since the mid seventies, together with the global energy developments over the past few years, have created a strong recognition of the need for overall energy planning and coordination. One of the top priorities has been to enhance Egypt's capabilities for integrated energy analysis based upon both energy resources and production factors on the supply side and energy consumption, conservation and economic planning factors on the demand side.

In order to address these issues - among other development considerations - institutional changes were introduced:

3.2. <u>The Production Sector</u>: In May 1980 a new cabinet was established on the basis of regrouping ministries into 3 main groups, each to be headed by a deputy prime minister. The Production Sector, which is headed by the Deputy Prime Minister for Production and Minister of Petroleum, includes in its membership the Ministers of Electricity, Industry, Agriculture, Irrigation, Transportation and Communications, and Military Production.

A coordinated and integral approach to the questions of national production is being applied both at the ministerial level and at the level of the operating departments and bodies. A weekly meeting of the Ministerial Production Committee brings the member ministers together to discuss all production policy matters. Among the key issues, subject to discussion and policy-making, are energy questions of top priorities such as conservation and the choice of new technologies proven to be energy-saving.

Some of these issues had already been considered and operative measures were taken; others have still to be considered or reconsidered as the case may be. In brief, energy has become one of the top concerns of the Production Sector and the energy-consuming sectors are becoming increasingly aware of the energy impact and related problems.

3.3 <u>The Supreme Council of Energy</u>: In 1979 decree 1093 was issued by the Prime Minister establishing the Council as the top-level body responsible for energy. Under this decree, the SCE, which is headed by the Deputy Prime Minister for Production and Minister of Petroleum, is given principal responsibility for planning short and long-term energy programs and for addressing and bringing to the President's attention major issues regarding energy. One of the major concerns of the SCE is to develop a strategy and a plan for the period 1980-1990. The plan should address the resources, production and consumption of energy needed to meet requirements of the economy, socio-economic development and the conservation of energy. The Council is also impowered to follow up the implementation of the plan and to amend it whenever necessary. The Council's Rapporteur, who is the Minister of Electricity, is entrusted with communicating the Council's resolutions to the Prime Minister and other concerned parties and with proposing the necessary measures for implementing these resolutions.

In addition to the Chairman and Rapporteur, the SCE includes in its membership the Ministers of Industry, Irrigation, Transport and Communications, Housing and Reconstruction, Finance and Planning, as well as the President of the Academy of Scientific Research and Technology and three selected members.

The Technical Secretariat of the SCE is responsible for preparing the agenda of the Council and for coordinating the efforts of three Work Groups entrusted with three main areas of concern: Resources, Production and Consumption. Each group is led by a rapporteur who is responsible for the execution of the jobs entrusted to his group. The group members are primarily representatives of the member ministries, but the group is empowered to entrust on a job basis any study to any individual or organization. Since the rapporteurs are also members of the Technical Secretariat there is assurance that the efforts of the individual Work Groups will be coordinated. Moreover, whenever the need arises, a subcommittee within the Work Groups is established to address special topics of joint interest.

The responsibilities of the Work Groups are briefly summarized as follows:

3.3.1. <u>Energy Resources Work Group:</u>

- preparing data about energy resources available in Egypt and carrying out studies to predict future resource availability;
- following up global developments in new, nontraditional energy resources;
- proposing a plan for utilization of traditional energy resources and carrying out the studies related to it; and
- proposing a realistic plan for utilization of new expected energy resources, specifying the priorities.

3.3.2. <u>Energy Production Work Group:</u>

- studying different energy production plans; and
- proposing plans for energy production projects during 1980-1990 based on information about available energy resources and demand. Consideration is to be given to the balance between demand and production in light of energy production economics for different resources. Varying assumptions about resource availability should be made to

consider the extent to which external resources would be required to achieve the required balance.

3.3.3. <u>Energy Consumption Work Group:</u>

- studying historical energy consumption of the various kinds of energy for all sectors and providing indications that may help to estimate future consumption; and
- carrying out studies that may help to identify ways to conserve energy in different sectors.

3.4. <u>Energy Research and Development:</u> Several bodies and institutions have been, for a long time, active in the field of energy R & D. The most important of these institutions are : universities, the National Research Center and its Solar Energy Laboratory, the Egyptian Petroleum Research Institute, the Agricultural Research Center, etc. The Academy of Scientific Research and Technology has also initiated specialized research councils including, among others, the Research Council for Energy, Petroleum and Mineral Resources.

Much of the research activities of these institutions has in recent years been directed to address the pressing need to develop new and renewable energy sources. The national energy strategy entrusted with the SCE envisages the provision of more additional financial and technical support to these institutions, as well as a stronger degree of coordination.

Section (4) of this paper will describe in more detail some aspects of these research activities.

3.5. NRSE in Application: Several ministries and companies, public as well as private, are undertaking the responsibility of demonstration and commercialization activities in the field of NRSE. The most important among these institutions is the Ministry of Electricity which initiated several bodies to handle various aspects of these responsibilities: a council headed by the Minister to deal with policy matters, an authority to monitor implementation, and a company to manufacture equipments. More recently, with financial support of the EEC, the Ministry of Electricity is undertaking a feasibility study to establish an independent body for NRSE.

4- New and Renewable Energy Sources in Egypt, Background Experience and Activities

A variety of new and renewable energy sources is available in Egypt. These include: solar, wind, hydro and biomass. Other prospective resources encompass oil and carbonaceous shales and geothermal which have yet to be evaluated. Several Egyptian institutions are active in the field of new and renewable sources of energy. Activities cover the domains of research, development, demonstration and fabrication of equipment.

4.1. Solar Energy:

4.1.0. Introduction: Because of its location and dry climate, Egypt has a very high incidence of solar radiation. In winter the sun shines for between 7 and 9.5 hours. In summer, sunshine is available for 12 hours. Direct solar intensity varies between 260 and 420 cal/cm^2 - day in winter, and is about 710 cal/cm^2 - day in summer. Storms are the main causes of obstruction of direct solar insolation.

4.1.1. Basic Studies: These encompassed: resource evaluation and solar mapping as well as a number of design and performance studies on solar stills, solar heating, central tower receivers systems, solar pumping, solar dehydrating, refrigeration and solar equipment manufacture in Egypt.

4.1.2 Research & Development Egypt has an extensive R&D programme, basically in the solar energy laboratory of the National Research Centre (NRC)in addition to the universities and the Ministry of Electricity (MOE).

A) National Research Centre:

- Different models of solar water heaters and solar stills were designed, manufactured and tested.
- In collaboration with the Federal Republic of Germany, a distillation plant incorporating five stills of different designs is under investigation for performance & economics.
- Various designs of solar concentrators have been investigated. These included:North-south fixed axis parabolic trough,vertical axis parabolic trough,heliostat-parabolic dish combination designed for steam generation, and combined parabola-cylinder-parabolic concentrator.
- Operation, testing and development of a 10 KW power generation plant through agreement with the Federal Republic of Germany.
- With support from IDRC of Canada, a vegetables dehydration unit was designed, built and successfuly operated completely by local efforts.
- An ammonia/water absorption cold store is in operation in collaboration with the Federal Republic of Germany.

- Investigation of CD and CD-TE solar cells by the NRC Solid-State Laboratory and the Laboratory of Bellevue (France).

B) Universities: Egyptian universities are embarking on extensive R & D programmes. In Cairo University investigations are being carried out on field flat plate collectors, solar concentrators and solar energy electro-chemical storage. Ain Shams and Helwan Universities have recently started R & D programmes on solar heating and dehydration systems. Alexandria University is undertaking a programme including water heating, dehydration, sea water desalination and has very recently concluded an agreement with the University of Eindhoven (Holand) for semi-manufacture of solar silicon cells and modules assembly as a start for the manufacture of solar cells in Egypt. El-Minia University started in 1978 an R & D programme for crop drying and thermochemical hydrogen production.

C) Ministry of Electricity: Through cooperation with "CEA" of France, a solar heliothermic laboratory for the evaluation of flat-plate solar collectors performance has recently been established. Besides a heliometric lab for the assessment of solar and wind resources are in operation since two years, together with 6 mobile recording unites in different sites of Egypt. The MOE is also testing solar water heaters under different Egyptian climates.

In addition, few investigations are being carried out on such aspects as the effect of environmental conditions on flat photovoltaic panels and evaluation of night cooling phenomenon.

4.1.3 Demonstration Projects: Several demonstration projects are executed or planned by various institutions in order to enhance the public awareness, train technical personnel and above all to assess the technical and socio-econimic feasibility of the new technologies under actual Egyptian conditions.

A) Ministry of Electricity:

- The MOE has imported 1000 solar water heaters of different types and sizes and distributed them on rental basis with very soft terms of payment to encourage Public use of solar water heaters and promote market penetrations.

- Through bilateral cooperation with France, three heaters with capacities of 150,1500 and 5000 liters/day were installed at a hospital in Cairo.

- The Egyptian-French agreement included also the supply joint installation, operation and testing of:

  - A solar reverse osmosis desalination plant with a capacity of 60 cu.m./day fresh water has already started operation at al Hamrawain phosphate mining site on the Red Sea coast.

- A 10 kw sofretes deep freezing unit operated by solar power is installed at the High Dam Lake in Aswan for fish preservation. The cooling water of the plant is used for irrigation of the adjacent area.

- The cooperation agreement between MOE and the Federal Republic of Germany includes:
  - 10 kw photovoltaic demonstration plants as follows: 2 kw irrigation pump, 2 kw desalination plant, 2 kw water purification plant, 1 kw drinking water pump, 0.12 kw 2 sea bouys,0.03 kw television set,0.5 kw spraypant, 1.3 kw food cold store and 1.26 kw water electrolysis unit. Some of these are already in operation.
  - A 50 kw solar absorption air conditioning system for a section of a hospital.

B) <u>The National Research Centre</u> :

- The Federal Republic of Germany through the NRC had donated 80 solar water heaters of 120 lit/day capacity which were installed in a village in the middle of the Delta.

- In the context of its rural development programme in the Governorate of Giza, the NRC started demonstration of a dehydration unit in one of the Giza villages.

C) American University at Cairo (AUC)

The AUC has two solar demonstation projects:

- El Basaisa Project: through cooperation with the U.S. National Science Foundation, the AUC introducted different solar devices in the village of Basaisa. Social studies are also going side by side with the training of villagers in the use of these techniques.

- Sadat City Project: Sadat City is one of the new desert cities intended to absorb portions of the increasing population. The AUC in cooperation with the MOE initiated a demonstration project on 200 acres. The object is to demonstrate the possibility of meeting the energy requirements of small and medium-sized farms as well as small agro-industries entirely from renewable energy sources including solar, biomass and wind systems.

4.1.4. Manufacturing Capabilities: Four firms for producing solar water heaters have started their activity within the last two years. The rated capacity of each is about 3000-4000 heaters per year. Heater capacities vary from 150 to 500 lit/day.

4.2. Wind Energy:

4.2.0. Introduction: Egypt has several locations with average daily and annual wind speeds high enough to be considered for the development of wind-power generators. The available data indicate that Mersa Matruh region on the Mediterranean Sea has an annual averge wind speed of about 20 Km/hr and the Hurghada region on the Red Sea coast has an annual average wind speed of about 22 Km/hr.

4.2.1 <u>Basic Studies:</u> The Ministry of Energy and Electricity together with the University of Oklahoma with support from U.S. Aid have conducted a research programme to measure wind speed and duration in Egypt. This programme has two phases.

Phase one had been under way since 1972 and was basically a resource availibility study. It dealt mainly with the gathering of existing wind data to select the promising areas for wind energy exploration. Phase two started in 1978 and dealt mainly with measuring wind speeds and duration in some preselected location. Such measurements have been done in Mersa Matruh , Ras El Hekma, Sidi Abdel Rahman along the north coast (Mediterranean), Safaga, Hurghada and Ras Gharib along the Red Sea coast.

Several basic studies concerning design performance of different wind mills and generators suitable for electricity generation under the unsteady wind conditions are underway at Cairo,Alexandria and Helwan Universities.

4.2.2. Research & Development:

- The Mechanical Engineering Laboratory of the NRC together with the Intermediate Technology and Development Group (ITDG) in U.K. are undertaking a project to develop a new design of a wind-turbine driven water pump of the low lift type for irrigation purposes. Modification and development include facilities for local manufacture of the prototype, site selection for installing the prototype, and preliminary testing under the field conditions. The tests aim at determining the performance capabilities and identifying the development needs.

- A project to select and test the most suitable commercially available type of wind mills under Egyptian climate. The main object is to introduce the necessary design changes in the selected type in order to facilitate its local manufacture. This project is a joint work between the Ministry of Electricity and Cairo University.

- Several other experimental and basic research studies on laboratory scale are being conducted at the universities.

4.2.3. Demonstration and Manufacture: The Manufacture of wind mills in Egypt started in the early sixties when the Helwan Company for Military and Civil Industries built almost 1000 wind powered irrigation pumps (with a turbine diameter of 2.45 m). Most of them have been installed and demonstrated along the north west coast. Some weakness in the design coupled with the lack of maintenance have caused the production to cease.

4.3. Hydropower:

4.3.1. Large-Scale Schemes: Egypt has long experience in the field of large scale hydroelectric power schemes. This is manifested by the fact that about 55% of the present electric energy demand is supplied through hydroelectric generation.

The existing hydroelectric power facilities on the Nile River are at the High Dam and the Aswan Dam with installed capacities of 2100 and 345 MWe respectively. Currently two thirds of the available hydropower are utilized. Existing plans include Aswan II Hydropower Station with 270 MWe installed capacity. The Qattara Depression Project is currently under study and may be constructed with a base capacity of 600 MWe before 2000. Moreover, there is potential for pumped-storage generation on the Red Sea. A capacity of about 2000 MWe in the Suez area has been investigated and found feasible for development.

4.3.2. Minihydro Power: Agriculture in Egypt depends mainly on the Nile River with its branches, major and minor canals. In some places in the Delta, the intakes to the main canals are operated at such heads which would reasonably allow small-scale hydro power installations.

A series of tests have been carried out and relevant data have been collected and analyzed covering about 34 possible sites. The preliminary techno-economic assessment indicated that a total production of 250 gwh per annum may be developed at competitive costs. Two thirds thereof, represented by sites of Damietta and Rosetta branch barrages, Zefta barrage and Dairout Drain barrage, refer to heads in the range of 3 to 5meters, which can be harnessed with conventional turbines. However, at another 10 sites of heads in the range from 1.3 to 2.1 m, the only economically justifiable layout appears to be with " Water Wheel " turbines, mounted immediately downstream of the gates of the present intakes.

4.4 Biomass Energy

4.4.0 Introduction : Egypt has a good deal of experience in the production of alcohols and acetic acid by fermentation. At present, some 76000 tons per annum molasses are fermeted to ethanol and acetone/butanol for hospital and specialized use rather than for fuel uses. Its use as fuel under the current local energy pricing system would hardly be justifiable. the main activities in the field of biomass energy are presently concentrated on biomethanation relating to 'Biogas' systems for rural areas use.

The major sources of energy available to most Egyptian villages are the non-commercial sources (dung cakes and agricultural wastes), which are estimated to have provided about one-fifth of the total energy consumption in Egypt in 1975. The present use of biomass in Egypt often involves open fire which is inconvenient for use and pose a health hazard due to heavy concentration of smoke in the building. Consequently, rural people tend to switch to kerosene or butane stoves as soon as finances permit. In fact, there is a significant demand on commercial energy sources in rural areas, and consumption of petroleum products is increasing very rapidly, almost doubling every 6 years. It is worthy to note that these petroleum products are very heavily subsidised by the government.

Agro and food industries wastes are another source. Substantial quantities of urban refuse and sewage are also available and can be used as an energy source.

4.4.1 Basic Studies : A number of basic studies are conducted by the National Research Centre (NRC) and the Agricultural Research Centre (ARC) to examine the technical, social and economic feasibility of biogas systems.

In the NRC a rough estimate was made of the biogas that could be produced by utilization of crop residues already used as energy sources as well as animal and human wastes available in Egyptian villages. This indicated that the biogas could provide the major portion of the residential rural energy requirements, i.e. substiuting for all the non-commercial sources as well as kerosene and butagas. Furthermore, an additional amount of organic fertilizer equivalent to more than 12 million tons of farm yard manure would be produced, which would otherwise be lost through the direct burning of crop residues and dung cakes. This is also very important since it is estimated that the present deficit in farm yard manure in Egypt of more than 80 million tons per year.

Preliminary cost-benefit analyses indicate that rural biogas systems may be feasible under certain conditions; particularly if the unit is connected directly to both the latrine and animal shed. Under these conditions, a payback period of less than five years is anticipated .

4.4.2 <u>Research and Development</u>: Although laboratory scale work on the anaerobic fermentation of animal wastes started in Egypt in the fifties, research endeavours on biogas production from agricultural animal and human wastes was only intensified in universities and research institutes since the early seventies.

A great deal of multidisciplinary R&D work was conducted in the NRC since 1978 as a component of a national R&D and demonstration programme financially supported by the U.S. Aid.

Considerable digestibility research work was done to determine optimum conditions conducive to greater efficiency, highest pathogens destruction rates and diminishing the effect of toxic and inhibitory materials. Various substrates including cow dung, sewage and agricultural wastes (weeds, water hyacinth, maize and cotton stalks) were investigated at different mixing ratios, organic loading and temperature. Certain pretreatments including pre-composting were also examined. Laboratory research was as well conducted on two relevant problems: the selective inhibition of hydrogen sulphide, and destruction of ova and embryos of ascaris.

A sizable portion of work was done on the evaluation of digested products as fertilizer and soil conditioner: As well as on their handling, storage and application.

The engineering and development work was directed towards design, construction, operation and testing of three family -size prototype units at the demonstation site of the National Research Centre as well as development of local appropriate gas-use devices. The first prototype unit is a fixed roof 10 m^3 rectangular digester of Chinese design. the second is a 6 m^3 cylindrical wide, shallow type dome-roofed Chinese digester. It is anticipated, after the experience gained with construction of the second prototype and its successful operation for almost a year, that this type has good prospects as a family-size unit in rural areas of Egypt. It presently costs around US $300 using locally available materials and skills. The third prototype unit, which has been recently constructed, is a new adapted design combining the features of both plug flow and the Indian movable cap types. Its effective size is about 7 m^3 and costs around $500. Provisions for solar heating of feed water, composting of the digester effluent on the top of the plug flow part, and attachment to both a latrine and an animal shed were incorporated in the unit. This type seems readily expandable to the community size.

The National Research Centre demonstration site, with all the biogas systems present, is also utilized for training as well as for publicising the biogas technolgy.

Thirty - three units 0.3m^3 each of both the Chinese fixed dome and the Indian movable gas holder types are being tested under various operating conditions by the Agricultural Research Centre.

4.4.3 Demonstration: Few field demonstrations have already started to assess the technical, economic and social viability of biogas technology in rural areas of Egypt.

The NRC demonstration programme started with two family size units (10 cu.m. each) of the Indian and Chinese types in a traditional village in Giza. The newly developed Egyptian type will also be demonstrated. A community-scale unit is under consideration as well.

The Ministry of Agriculture has also initiated a locally funded demonstration programme. Three 10 m3 Indian type units have been recently installed, in addition to a 45 m^3 unit attached to a chicked farm (the gas is used for heating the chicken chambers). Recently, the FAO has strengthened these activities by releasing a "TCP" project for one year whereby 50 biogas units will be constructed and demonstrated.

4.5. Oil And Carbonaceous Shales: Oil shale deposits have been located in four places, but no reserve estimates have been made. Available data indicate that the shale is of low quality and could be exploited only if there were a severe lack of alternatives.

Some carbonaceous (lignitic or coaly) shale is also available in limited quantities but it has not been evaluated for extent of reserves of potential uses.

4.6. Geothermal Energy: Very limited information is currently available on the extent of geothermal energy sources in Egypt. Its potential, however, has been noted by the presence of hot springs on the east and west sides of the Gulf of Suez and in several cases by higher than normal heat flows along the west coast of the Red Sea, by hot wells in the Western Desert, by evidence of extinct geysers east of Cairo toward Suez, by mineral springs in the Helwan area and evidence of extinct hydrothermal activity in the Qatrani area.

The Egyptian Geological Survey and Mining Authority in collaboration with Southern Methodist University undertook a 2 year joint geophysics project. Results indicate that most promising areas for geothermal development in Egypt are along the Red Sea coast.

4.7. Potential Applications: In a recent joint Egyptian/ U.S. AID assessment of renewable energy resources and priorities, some areas with good prospect for application in Egypt have been

The National Research Centre demonstration site, with all the biogas systems present, is also utilized for training as well as for publicising the biogas technology.

Thirty - three units 0.3m^3 each of both the Chinese fixed dome and the Indian movable gas holder types are being tested under various operating conditions by the Agricultural Research Centre.

4.4.3 Demonstration: Few field demonstrations have already started to assess the technical, economic and social viability of biogas technology in rural areas of Egypt.

The NRC demonstration programme started with two family size units (10 cu.m. each) of the Indian and Chinese types in a traditional village in Giza. The newly developed Egyptian type will also be demonstrated. A community-scale unit is under consideration as well.

The Ministry of Agriculture has also initiated a locally funded demonstration programme. Three 10 m3 Indian type units have been recently installed, in addition to a 45 m^3 unit attached to a chicked farm (the gas is used for heating the chicken chambers). Recently, the FAO has strengthened these activities by releasing a "TCP" project for one year whereby 50 biogas units will be constructed and demonstrated.

4.5. Oil And Carbonaceous Shales: Oil shale deposits have been located in four places, but no reserve estimates have been made. Available data indicate that the shale is of low quality and could be exploited only if there were a severe lack of alternatives.

Some carbonaceous (lignitic or coaly) shale is also available in limited quantities but it has not been evaluated for extent of reserves of potential uses.

4.6. Geothermal Energy: Very limited information is currently available on the extent of geothermal energy sources in Egypt. Its potential, however, has been noted by the presence of hot springs on the east and west sides of the Gulf of Suez and in several cases by higher than normal heat flows along the west coast of the Red Sea, by hot wells in the Western Desert, by evidence of extinct geysers east of Cairo toward Suez, by mineral springs in the Helwan area and evidence of extinct hydrothermal activity in the Qatrani area.

The Egyptian Geological Survey and Mining Authority in collaboration with Southern Methodist University undertook a 2 year joint geophysics project. Results indicate that most promising areas for geothermal development in Egypt are along the Red Sea coast.

4.7. Potential Applications: In a recent joint Egyptian/U.S. AID assessment of renewable energy resources and priorities, some areas with good prospect for application in Egypt have been identified. These are:

1. Solar domestic water heating.
2. Solar collectors for industrial process heat.
3. Solar desalination.
4. Rural biogas digestors.
5. Photovoltaic for remote application.
6. Passive solar architecture for new settlements.
7. Solar flat plate collectors for refrigeration and cooling.
8. Wind systems for water pumping and electrical generation.

4.8. Future Work in the Field of NRSE:

Future work in the field of NRSE will involve technical and economic assessment of technologies and their wide implementation under local conditions. Among other things, this would include institutional restructuring that better meets the future needs, establishing a reliable data base as well as intesifying and widening educational and training programs.

The following is an outline of the areas that are of special importance in the future R+D+D program:

1-Enhance designing and local manufacturing capability of flat-plate solar heaters for domestic hot water and preheating in industrial processes.

2- Design and construction of solar thermal systems to replace conventional energy sources for industrial processes heat, including the enhancement of industrial capabilities of moderate temperature solar collectors (100 ^{o}c - 250 ^{o}c).

3- Demonstration and development of different bioclimatic building designs to suit the different climates and cultural conditions.

4- To enhance the Egyptian capabilities to design, construct and operate solar desalination plants on the Mediterranean and Red Sea coasts.

5- Development of solar drying of agricultural products.

6- Technical and economic assessment of solar-wind power generation system for different applications with emphasis on demonstration plants in remote areas.

7- Technical and economic assessment of available solar pumping systems including demonstration testing under Egyptian conditions.

8- Investigation of direct and indirect utilization of solar energy for hydrogen production.

9- Production of less costly photovoltaic cells, and investigation of the most appropriate storage systems.

10- Investigation of the feasibility of solar pond systems in Egypt.

11- Use of municipal wastes and garbage for biogas production in big cities.

12- Investigation of integrated biogas systems incorporating algae, fish, and fertilizer.

13- More active demonstration of small biogas systems in rural areas.

14- Energy farming in semi-arid and arid land.

15- Amelioration of alcohol productivity from agricultural wastes including, beside other aspects, the bio-conversion of the lignin component of the wastes.

16- Studies on the most proper types, and designs of wind energy systems for water pumping and electricity generation.

17- Assessment of oil shales and tar sands in Egypt.

18- Feasibility study on the prospects of geothermal energy in Egypt.

5- Major Constraints and Policy Measures

5.1. Technologically, Egypt has a wide and diversified expereince in the field of conventional energy as well as in several fields of NRSE. Solar energy research has been going on in universities and specialized laboratories for over 25 years. Biomass and wind energy have also received special attention. However, the energy impact of recent years has created an urgent need to intensify and redirect research and development activities to meet the fast accelerating future energy demands.

5.2. Several constraints to the new course may be mentioned in brief:

5.2.1. Under the present energy system, the pricing of petroleum products is characterized by a great deal of rigidity. Domestic prices do not exceed one third of the international energy prices and for some products like fuel oil may not exceed 10%. Tacit subsidies in domestic oil consumption are estimated at $ 2330 million for 1980/1981. Much has to be done in restructuring the energy pricing system, but there are serious obstacles that need first to be tackled:

(a) Since most wages and prices of necessary commodities are controlled by government actions as a measure against inflation, wages and costs have to be reconsidered to match and balance energy price restructuring. This problem is receiving utmost consideration at all political and social levels.

(b) The lack of alternative energy sources. Solar water heating, which is being developed at a fast face, may only provide partial help by offsetting part of the ever increasing butagas consumption. Butagas consumption, which is partly imported and subsidized, has been growing at an annual rate of about 20%.

The fast development of natural gas may also help relieve the problem but it does not offer a long-range solution in view of its depletable nature.

Despite these obstacles, a partial restructring of oil prices has been initiated during 1980. For certain projects whose products do not affect the low-income classes, a phased-out system to bring the prices of their energy requirements up to the world level in 5 years has been adopted and accepted by the projects managers. Parallel measures are being considered to bring all energy prices to the required level without affecting the real incomes of the low-income classes.

5.2.2. The fact that Egypt had not faced in the past a severe energy crisis, and that oil had been available in enough quantities to meet the relatively low level of consumption, hindered to some extent the pace of energy assessment and planning. Now, the challenge is becoming greater and the past policies are increasingly changing. Senior officials and their staffs exhibit a high level of awareness about the major policy issues and are highly dedicated and competent. And, as was mentioned before, Egypt has taken important steps in integrating its economic goals with its energy prospects by the establishment of the Supreme Council of Energy and by regrouping several ministries in form of a Production Sector, both under the chairmanship of one Deputy Prime Minister. What may make it easeir to plan and to implement, is that the greater part of economic and development activities is undertaken by public sector personnel who can easily comply with public policies, once ratified by public authorities. Lucky enough, a great deal of development projects and housing reconstruction program, including the establishment of several new cities, is to be acheived in the future, hence the chance is there to choose the energy-saving technologies.

The energy assessments carried out to date have to be up-dated and an energy data system is being considered to meet the new requirements. There is a great chance in this area for regional and international cooperation, part of which has already started on a bilateral basis. Needless to say that the Egyptian infrastructre in the feild of energy research and development and manpower training could serve as a solid base for new regional energy centers once the technical and financial support is available in adequate amounts.

5.2.3. In brief, the need for comprehensive energy planning centers around a number of critical issues that must be addressed in the context of a broader national perspective. These issues include among others :

(a) Subsidies in energy prices and the need to restructure these prices within the specific framework of economic and social structure that prevail in Egypt.

(b) The role of energy in the economy.

(c) Planning for the development of new and renwable resources of energy.

(d) Ways and means to effect energy conservation.

(e) Investment in power generating capacity and the need to replace oil in this field by other cheeper sources of electricity generation.

(f) The need to accelerate regional and international cooperation in the above fields, taking into considerations the special qualifications of Egypt as a member of both ECA and ECWA.